A bottom-up quantification of foliar mercury uptake fluxes across Europe

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The exchange of gaseous elemental mercury, Hg(0), between the atmosphere and terrestrial surfaces remains poorly understood mainly due to difficulties in measuring net Hg(0) fluxes on the ecosystem scale. Emerging evidence suggests foliar uptake of atmospheric Hg(0) to be a major deposition pathway to terrestrial surfaces. Here, we present a bottom-up approach to calculate Hg(0) uptake fluxes to aboveground foliage by combining foliar Hg uptake rates normalized to leaf area with species-specific leaf area indices. This bottom-up approach incorporates systematic variations in crown height and needle age. We analyzed Hg content in 583 foliage samples from six tree species at 10 European forested research sites along a latitudinal gradient from Switzerland to northern Finland over the course of the 2018 growing season. Foliar Hg concentrations increased over time in all six tree species at all sites. We found that foliar Hg uptake rates normalized to leaf area were highest at the top of the tree crown. Foliar Hg uptake rates decreased with needle age of multiyear-old conifers (spruce and pine). Average species-specific foliar Hg uptake fluxes during the 2018 growing season were 18 ś 3 ţg−2 for beech, 26 ś 5 ţg−2 for oak, 4 ś 1 ţg−2 for pine and 11 ś 1 ţg−2 for spruce. For comparison, the average Hg(II) wet deposition flux measured at 5 of the 10 research sites during the same period was 2.3 ś 0.3 ţg−2, which was 4 times lower than the site-averaged foliar uptake flux of 10 ś 3 ţg−2. Scaling up site-specific foliar uptake rates to the forested area of Europe resulted in a total foliar Hg uptake flux of approximately 20 ś 3during the 2018 growing season. Considering that the same flux applies to the global land area of temperate forests, we estimate a foliar Hg uptake flux of 108 ś 18. Our data indicate that foliar Hg uptake is a major deposition pathway to terrestrial surfaces in Europe. The bottom-up approach provides a promising method to quantify foliar Hg uptake fluxes on an ecosystem scale.
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